REMARKS

Claims 1-10 are pending in the present application. Claims 1-4 were rejected under 35 U.S.C. §103(a) as being unpatentable over U.S. Pub. No. 2003/0037815 to Kim et al. ("Kim") in view of U.S. Pat. No. 4,748,130 to Wenham et al. ("Wenham") and further in view of U.S. Pat. No. 5,081,049 to Green et al. ("Green"). Claims 1-2 and 4 were also rejected under 35 U.S.C. §103(a) as being unpatentable over an article entitled *Solar Cells Based on a New Junction Transparent Conductor/Thin Insulator Having Ultrafine Metal Islands/Semiconductor* by Nakato et al. ("Nakato") in view of Wenham and Green. Claim 3 was rejected under 35 U.S.C. §103(a) as being unpatentable over Nakato in view of Wenham and Green and further in view of Kim. Claims 5-10 were withdrawn from consideration based on Applicant's election made in the February 18, 2010 response.

Claims 1-4 have now been amended. It is respectfully submitted that no new matter has been added. Claims 5-10 have now been canceled without prejudice. Reconsideration of the application in view of the foregoing amendments and following remarks is respectfully requested.

Rejections Under 35 U.S.C. § 103(a)

Claims 1-4 were rejected under 35 U.S.C. §103(a) as being unpatentable over a combination of Kim, Wenham and Green. Claims 1-2 and 4 were also rejected under 35 U.S.C. §103(a) as being unpatentable over a combination of Nakato, Wenham and Green. Claim 1 of the present application has now been amended. Support for the amendment may be found at page 4, line 14 – page 5, line 13, and page 6, lines 1-28 of the specification as originally filed, and in Figure 1. It is respectfully submitted that none of Kim, Nakato, Wenham, and Green, or their combination, teach or suggest at least a photovoltaic solar cell having the following features recited in amended claim 1:

> metal nano emitters (NE) form a Schottky contact and are three-dimensionally structured in an acicular or rib-like manner and are separated from each other by a uniform distance $D \leqq \sqrt{2}L$ and penetrate into the semiconductor layer to a depth
>
> $T \geqq d_{HL} - \frac{L}{2} + w$.

In contrast, Kim merely describes a solar cell with a pn junction 30 between two planar semiconductor layers 10, 11 of opposite conductive types. One of the polarized semiconductor

layers of Kim forms a single planar emitter. See Kim, par. 0026. Thus, Kim does not teach or suggest a plurality of metal nano emitters that form a Shottky contact and are three-dimensionally structured in an acicular or rib-like manner, as required by claim 1. First, the front electrodes 19a of Kim are not metal emitters, but arrestors for carriers. See Kim, par. 0056. Furthermore, as those skilled in the art will appreciate, in a Shottky contact as now recited in amended claim 1, carriers are generated and separated at the junction between the semiconductor and the metal. The Shottky contact recited in claim 1 does not have a pn junction. In contrast, Kim relies on the semiconductor layer 11 to form a single planar emitter. See Kim, par. 0026 (discussing semiconductor layers 10 and 11 having conductive types opposite to each other in polarity); Figure 1 (showing a planar emitting semiconductor layer 11). The emitting semiconductor layer 11 of Kim forms a plane across the pn junction 30 and, therefore, is not structured in a rib-like manner. Therefore, Kim does not teach or suggest a plurality of metal nano emitters that form a Shottky contact and are three-dimensionally structured in an acicular or rib-like manner, as required by claim 1.

Applicants further note that the electrodes 19a, 19b of Kim are surrounded with heavily doped semiconductor regions 18a, 18b to produce back scattering fields and reduce carrier loss. See Kim, par. 0031, Figure 1. However, persons skilled in the art will realize that doping cannot be successfully carried out in the nano range since diffusion of donors and acceptors cannot be controlled at such small dimensions. Applicants respectfully submit that Kim is thus nonfunctional at the nanoscopic scale, and therefor cannot teach or suggest nano emmiters [forming] a Shottky contact, as required by claim 1.

Regarding Wenham, Applicants respectfully note that, like Kim, Wenham also requires a solar cell with a pn junction and a planar semiconductor emitter layer. See Wenham, col. 3, lines 20-24; Figure 1 (showing an n-type emitter layer 10, a p-type layer 12, and a groove 13 formed in the n-type layer for a metal contact 14). Hence, Wenham is subject to the same doping limitations and does not scale to the nanoscopic range as discussed above with respect to Kim. Therefore, Wenham is limited to microscopic scale (i.e., to dimensions larger than nano scale by a factor of a 1000). See Wenham, col. 3, lines 57-60 (limiting the minimum size of the groove width Wg to "preferably > 25μm"). Hence, the contact width and depth dimensions in Wenham cannot be optimized to the nanometer size. Therefore, Wenham does not teach or suggest metal nano emitters

that form a Shottky contact and penetrate the semiconductor layer to a depth $T \geq d_{HL} - \frac{L}{2} + w$, as required by claim 1.

Regarding Green, that reference merely discloses structuring of the surface of anti-reflex layers of silicon solar cells and does not relate to spacing of the emitters. Therefore, Green does not teach or suggest metal nano emitters that are separated from each other by a uniform distance $D \leqq \sqrt{2}L$, as recited in claim 1. Instead, Green discusses tapering cones (with interposed grooves) spaced so as to increase the absorption of the incident light by the anti-reflex layer of the solar cell. See Green, Abstract; col. 4, lines 44-67; Figure 1 (showing paths of reflection of incident light 6 within the grooves 2 formed by "upstanding structures 1" in the silicon surface). Green requires multiple reflections of incident light to take place within the protruding surface structures. Green, col. 5, lines 1-3. Since the incident light must pass through and reflect within the grooves 2 and structures 1 of Green, the grooves of Green are empty and cannot contain the metal emitters for the light to be passed through. Hence, groove spacing discussed in Green is unrelated to spacing of the emitters recited in claim 1. Therefore, Green does not teach or suggest "metal nano emitters ... separated from each other by a uniform distance $D \leqq \sqrt{2}L$," as recited in claim 1.

Similarly, all other surface and groove shapes shown in Green, including those in Figure 6, include empty grooves which can not contain emitters for the light to be properly reflected within and absorbed into the layer below. Therefore, the groove shapes shown in Green do not teach or suggest "metal nano emitters ... with lateral branches and/or extend obliquely in the semiconductor layer," as recited in claim 2.

Regarding Nakato, Applicants respectfully note this reference requires that the "islands of metal," shown in Figures 1 and 2, "are deposited on the surface" of the silicon layer. See Nakato, page 940, left column, lines 1-4; Figures 1-2 (emphasis added). The metal island emitters of Nakato are two-dimensionally structured in a dotted fashion (e.g., as "islands") and are present only at the surface of the semiconductor layer without penetrating therein. Therefore, Nakato does not teach or suggest metal nano emitters that are three-dimensionally structured in an acicular or rib-like manner and penetrate into the semiconductor layer, as required by claim 1. By contrast, as shown in Nakato Figures 1-2, the metal emitters of Nakato are nearly flat two-dimensional "ultrafine" dots or islands

that merely act as conductive contacts on the front surface of the semiconductor layer and do not penetrate inside to collect the carriers within this layer. See also Nakato, page 940, left column, bottom paragraph ("metal islands are ultrafine."). The island emitters of Nakato are clearly not structured in an acicular or rib-like manner. Therefore, Nakato does not teach or suggest "metal nano emitters … are three-dimensionally structured in an acicular or rib-like manner … and penetrate into the semiconductor layer," as required by claim 1.

As discussed above, Wenham limits its dimensions to above 25 μm and cannot be optimized to the nanoscopic scale, while the grooves cited in Green cannot contain metal emitters. Therefore, a combination of Nakato, Wenham and Green, in addition to missing the foregoing elements of claim 1, would be nonfunctional at the nanoscopic range of Nakato and, therefore, improper.

Therefore none of the references teaches or suggests "metal nano emitters (NE) form a Schottky contact and are three-dimensionally structured in an acicular or rib-like manner and are separated from each other by a uniform distance $D \leqq \sqrt{2}L$ and penetrate into the semiconductor layer to a depth $T \geq d_{HL} - \frac{L}{2} + w$, as recited in claim 1. Thus, any combination of Kim, Wenham, Green, and/or Nakato, to the extent proper, could not render claim 1, or any of its dependent claims 2-4 obvious.

Reconsideration and withdrawal of the rejection of claims 1-4 under 35 U.S.C. §103(a) based on Kim in view of Wenham and Green, of claims 1-2 and 4 under 35 U.S.C. §103(a) based on Nakato in view of Wenham and Green, and of claim 3 under 35 C.F.R. §103(a) based on Nakato in view of Wenham, Green and Kim is respectfully requested.

CONCLUSION

In view of the above amendment, Applicant believes the pending application is in condition for allowance.

The Commissioner is hereby authorized to charge any unpaid fees deemed required in connection with this submission, including any additional filing or application processing fees required under 37 C.F.R. §1.16 or 1.17, or to credit any overpayment, to Deposit Account No. 12-1216.

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Respectfully submitted,

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